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ABSTRACT

This paper illustrates the relevance and utility of non-parametric statistical tests, such as the Kolmogorov-Smirnov two sample test, for analysis of developmental phenomena. This statistic tests the null hypothesis that two samples have been drawn from the same population by comparing their whole distributions, rather than specific parameters and makes no assumptions about their shapes. This comparison allows one to test the assumption that the groups are similar on the pretest. The same test may be performed on post-test scores, or on the relative amount of change in each group's scores. Tables are provided which illustrate: (1) a comparison of a traditional analysis and a distribution analysis of change scores in an intervention study; (2) frequency distributions of changes in stage scores for social-cognitive measures by Loevinger, Kohlberg, and Selman; (3) an analysis of subjects who advance or regress over the length of a program; and (4) an analysis of change defined as showing reasoning characteristic of the next highest stage, not previously elicited. (Author/SS)

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Issues in the Analysis of Data In Developmental Interventions

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For some years now, I have been trying to convince my colleagues in structural cognitive developmental psychology that empirical research methods might be of use to them. My early professional training was in Engineering and Physics, but I found the social sciences to be much more interesting, with wide varieties of issues yet to be explored and countless unsolved problems.

My first reaction to reading Piaget was one of incredulity! Here was a respected scientist proposing models for problem-solving processes, and presenting examples of two or three children, all whose responses confirmed his models! Didn't children ever say anything outside his schema? Do all children say the same things? Why are many of the terms used so ill-defined or circular? Why are experiments described so vaguely that replication is near-impossible?

Now, several years later, with the help of my colleagues and several authors in the area, I've begun to understand some of the issues just raised and now realize why some of the data analyses I performed for them left them just as incredulous about statistics as I was about the "methode clinique."

Table 1 represents a traditional analysis of data realized in an intervention designed to provide sufficient cognitive conflict and stimulation to increase junior high school students' reasoning ability about moral and social issues. The context is a ten week unit in junior high school social studies called "Facing History and Ourselves: Holocaust and Human Behavior," authored by Margot Strom and Bill Parsons in Brookline, Massachusetts. There were experimental and control classes in two schools of differing social class and achievement. However, pretest measures and reading achieve-

ment levels were nearly equal for combined experimental and control groups. The analysis shows a statistically significant difference in level of reasoning about social dilemmas even after initial differences in reading level and pretest scores were controlled for. Happily, the difference favors the experimental group.

Today I would like to discuss the implications of such an analysis and offer some suggestions about alternative analyses readily available to, but often ignored by researchers in this area.

The first issue concerns the importance of testing the difference between two means, the average reasoning levels of the experimental and control groups. We might ask, "What is interesting about the average way thirty children solve a social or moral dilemma?" Or, we might be quite sophisticated in statistics and be concerned that the data is not continuous and is at best, ordinal, so that the arithmetic mean is an inappropriate measure of central tendency.

The second issue is concerned with describing change in subjects over time. What is required is a way of analyzing the stage responses in two groups at two times in a way that preserves the integrity of the data, yet allows us to determine the likelihood that any differences may be due to chance or random error. I would like to propose a well known, but seldom employed non-parametric analysis which deals with the two issues at hand: an alternative to group means and a repeated measure design on a variable which is ordinal at best.

Since subjects' scores are often recorded as a stage of reasoning or a transitional state between two stages, it is relatively easy to construct

a frequency distribution of subjects across stages. Then, if cumulative distributions for control and experimental groups are computed, they may be easily compared using the Kolmogorov-Smirnov two sample test. This statistic tests the null hypothesis that two samples have been drawn from the same population by comparing their whole distributions, rather than specific parameters and making no assumptions about the shapes. This comparison allows us to test the assumption that the groups are similar on the pretest.

If we are satisfied that the groups were similar on the pretest, we may choose to perform the same test on the post-test scores. Or, if we wish to find out whether the experimental group changed more than the control group, we may classify the subjects by the amount of change in their scores, considering the change from transition into consolidation, or vice versa, as a one-half stage movement. Then, once again, a frequency distribution of change scores may be calculated for both groups and compared using the two sample Kolmogorov-Smirnov test.

Table 2 represents the raw data for both experimental and control groups on the pretest (Time 1) and the posttest (Time 2). From these cross-tabulations it is possible to see who changed and how much.

Tables 2A and 2B illustrate the frequency distribution of changes in stage scores for Loevinger ego development, and issues within Kohlberg's system of stages of moral reasoning and Selman's stages of interpersonal awareness. The number of regressions is within the range of chance, as might be expected, given the interrater reliability of about 0.8.

A more coarse analysis is represented in Table 3. Here, the data are collapsed to compare subjects who advance or regress over the length of the program.

Table 4 shows the results of applying a more stringent criteria for change. Rather than merely consolidating reasoning already available to a subject in new settings, change here is defined as showing reasoning characteristic of the next highest stage, not previously elicited.

In these two cases, there are only two outcomes, for example, advancing or not, or exhibiting higher stage thinking or not. Here, the binomial test using the proportion attained by the control group as the P parameter and testing for the likelihood of the experimental group's proportion arising due to chance, serves as a test for comparing the two groups.

More elaborate analyses, beyond the scope of this paper, but presently under investigation, are concerned with change in subjects in several applications areas. Noting changes in the patterns of scores may allow alternative possibilities for empirically determining decolage. Then we can study change in even more complex senses and observe the presently ill-defined phenomena of emergence and consolidation.

The non-parametric tests have been available for many years, but the reluctance of structural developmentalists to employ any statistical analysis has prevented these tools from being used. Hopefully, this paper will show the relevance and utility of such techniques and aid the developmentalists in establishing their research on a more traditional scientific basis.

Table 1

Traditional Analysis

	Experimental			Control		
	N	M	S	N	M	S
Reading Level (1)	42	9.35	2.24	21	9.84	2.46
Interpersonal Awareness (1)	42	240.4	34.6	21	244.4	30.2
Interpersonal Awareness (2)	42	255.4	31.4	21	241.0	36.1

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Analysis of Covariance

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F
Experimental vs. Control	4,499.438	1	4,499.438	7.567*
Within groups	35,081.234	59	594.597	
Total	39,580.672	60		

*p = .008

Table 2

Proportions of Subjects at

Each Stage of Interpersonal Awareness

Experimental Group		Time 2			
		1(2)	2	2(3)	3
Time 1	1(2)	.00	.00	.02	.00
	2	.04	.09	.20	.02
	2(3)	.00	.02	.31	.09
	3	.00	.00	.04	.16

Control Group		Time 2			
		1(2)	2	2(3)	3
Time 1	2	.00	.29	.10	.00
	2(3)	.05	.10	.28	.09
	3	.00	.00	.05	.05

Table 2A

Proportion of Subjects Changing Their Stage Score

		EXPERIMENTAL							CONTROL						
		-1	-1/2	0	+1/2	+1	+1 1/2	N	-1	-1/2	0	+1/2	+1	+1 1/2	N
Personality	1C		.25	.58	.17			12		.44	.33	.22			9
Personality Change	1D	.08	.11	.46	.19	.15		26		.27	.33	.33	.07		15
Formation	2A	.05	.24	.43	.14	.11	.03	37		.38	.38	.19	.06		16
Closeness/ Intimacy	2B		.17	.50	.29	.04		24		.38	.31	.23	.08		13
Group Cohesion	2C	.03	.06	.41	.41	.09		32	.19	.00	.38	.25	.19		16
Trust/ Responsibility	2D	.03	.12	.41	.44			34		.31	.38	.31			16
Conformity	2E	.03	.10	.59	.24	.03		29	.07	.14	.50	.21	.07		14
Rule-Orientation	2F	.05	.10	.38	.24	.19	.05	21		.23	.62	.15			13
Decision-Making Organization	2G	.03	.12	.48	.24	.12		33	.06	.26	.50	.13	.06		16
Leadership	2H	.08	.08	.50	.33			12		.28	.57	.14			7
Jealousy/ Esclusion	2I		.40	.20	.20	.20		5		.33	.67				3
Conflict Resolution	2J		.23	.33	.29	.12	.03	34		.25	.65	.05	.00	.05	20
Termination	2K	.07	.07	.26	.44	.15		27	.08	.17	.50	.17	.08		12
Global	Global		.11	.56	.29	.04		45	.05	.14	.62	.19			21

Table 2B

Proportion of Subjects Changing Their Stage Score

	EXPERIMENTAL							CONTROL								
	-1	-1/2	0	+1/2	+1	+1 1/2	N	-1 1/2	-1	-1/2	0	+1/2	+1	+1 1/2	+2	N
Life	.04	.38	.46	.12			26		.10	.10	.60	.20				10
Law		.10	.43	.30	.10	.07	30			.18	.18	.18	.18	.09	.09	11
Morality/ Conscience		.25	.61	.14			28		.22	.22	.44	.11				9
Punishment	.04	.04	.48	.27	.04		26	.10	.10	.10	.40	.30				10
Contracts		.05	.67	.28			21			.11	.56	.33				9
Authority			.93	.07			14				1.00					5
GLOBAL		.11	.67	.22			37		.13	.13	.47	.20	.07			15
		.12	.66	.16	.06		50			.03	.53	.30	.13			30

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Table 3

Proportion of Students Who Change Their Stage Score

	Exp.		Control	
Interpersonal Awareness	-	+	-	+
Personality	.25	.17	.44	.22
Personality change	.19	.34	.27	.40
Formation	.29	.28	.38	.25
Closeness/Intimacy	.17	.33	.38	.31
Group Cohesion	.09	.50	.19	.44
Trust/Reciprocity	.15	.44	.31	.31
Conformity	.13	.27	.21	.28
Rule Orientation	.15	.48	.23	.15
Dec. Making/Org.	.15	.36	.32	.19
Leadership	.16	.33	.28	.14
Jealousy/Exclusion	.40	.40	.33	.00
Conflict Resolution	.23	.44	.25	.10
Termination	.14	.59	.25	.25
Global	.11	.33	.19	.19
Moral Judgment				
Life	.42	.12	.20	.20
Law	.10	.14	.18	.54
Morality/Conscience	.25	.14	.44	.11
Punishment	.08	.31	.30	.30
Contracts	.05	.28	.11	.33
Authority	.00	.07	.00	.00
Global	.11	.22	.26	.27
Ego Development				
Ego	.12	.22	.03	.43

Table 4

Proportion of Subjects Showing Reasoning at a New Stage

	Exp.	Control
Personality	.00	.00
Personality Change	.15	.07
Formation	.14	.25
Closeness/Intimacy	.04	.08
Group Cohension	.31	.25
Trust/Reciprocity	.18	.25
Conformity	.10	.21
Rule Orientation	.43	.08
Dec. Making/Org.	.30	.06
Leadership	.25	.00
Jealousy/Exlusion	.20	.00
Conflict Resolution	.29	.10
Termination	.37	.25
Global	.24	.10
Life	.04	.00
Law	.30	.55
Morality/Conscience	.07	.11
Punishment	.20	.30
Contracts	.05	.11
Authority	.00	.00
Global	.03	.13
Ego	.16	.20